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(54) Magnetic actuators

(57) Actuator (10), particularly for motor vehicle powered door locking systems, utilises a solenoid (12) exemplified in Figure 1 whose poles coact with poles of permanent magnets (16,18). Relative movement between the solenoid and magnets shifts a plunger (14) or lever to provide drive output. The solenoid is switched to give magnetic polarity at a solenoid pole coacting with a first permanent magnet pole (16a) unlike opposite to the polarity of the latter to provide an attractive force, while at the same time making the polarity of another solenoid pole which coacts with a second permanent magnet pole (18a) of like polarity to the latter to provide a repulsive force in the same direction. The plunger or the like is returned by reversing the current direction in the solenoid, driving the magnets in the opposite direction. A latching action holding the element at the selected position even when the solenoid is de-energised is provided by the engaged permanent magnet pole.

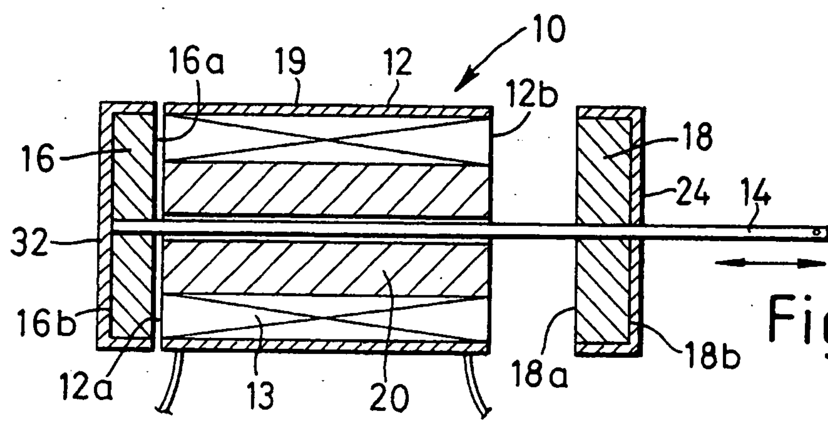

Fig.1

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Description

This invention relates to actuators, useful primarily but not exclusively in locking systems of motor vehicles. The actuator causes locking or unlocking (for example) by powered displacement of a component. The displacement may be rectilinear, but this can be converted into rotary motion. The displacement may be rotary or an angular movement of a component equivalent to movement of a part through part of a revolution about an axis, and such motions may be converted to rectilinear motion.

The invention is particularly applicable to the actuation of locking assemblies of vehicle doors and other closures such as boot lids, bonnets and petrol flaps for their remote operation as part of a central door locking (CDL) system of the vehicle in known manner.

Most power actuators in common use for vehicle locking and unlocking utilise miniature electric motors driving a gear train, rack and pinion arrangement, or screw threaded motion converter but these mechanisms are of complex construction requiring numerous precision components; occupy substantial space particularly as they have to be provided with housings to retain lubrication and protect them from dirt and moisture; are liable to wear and are not always durable; and may be unacceptably noisy in operation.

The object of the invention is to provide a power actuator of particularly simple, durable and compact construction requiring few moving parts and which is reliable, efficient and adaptable.

The invention provides an actuator and/or a vehicle locking assembly as defined by some one or more of the appended claims.

Examples of the invention are now more particularly described with reference to the accompanying drawings, wherein:

Figure 1 is a diagrammatic longitudinal section of a first form of actuator,
Figure 2 is a perspective view of a vehicle door locking assembly incorporating said actuator,
Figure 3 is a side view of said assembly in a locked condition,
Figure 4 is a like view thereof in unlocked condition,
Figure 5 is a diagrammatic sectional view of a second form of actuator,
Figure 6 is a perspective view of a locking assembly incorporating said second form,
Figure 7 is a diagrammatic elevation of a third form of actuator, and
Figure 8 is a perspective view of a locking assembly incorporating a modification said third form.

Referring to Figure 1, an actuator 10 includes a single solenoid 12 having coil windings 13 arranged in cylindrical shape about a hollow axis providing two poles 12a, 12b at its opposite ends. A substantially nonmagnetic rod 14 extends along that axis through the solenoid. Rod 14 is longer than solenoid 12 and is free to move axially therein. It carries permanent magnets 16, 18 of disc form at each end. The two permanent magnets are arranged in magnetic opposition, that is to say, their north poles 16a, 18a face each other and their south poles 16b, 18b are remote from one another. Alternatively the south poles face each other and the north poles are remote. When solenoid 12 is energised, the flux path has north magnetic polarity at one end of windings 13 and south polarity at the other end. One permanent magnet will be attracted by the adjacent flux of opposite polarity and the other repelled by the adjacent flux of like polarity. Consequently rod 14 will be forcibly axially displaced. Reversal of the electromagnetic field, by reversing the electrical connections to windings 13 as by suitable switch means (not shown) will reverse the electromagnetic field, and drive rod 14 in the opposite direction.

The stroke, i.e. drive distance will be dependant on the spacing between the like magnetic faces of magnets 16, 18 as compared to the total axial length of solenoid 12.

A number of factors affect the concentration and shaping of the electromagnetic field, as will be well understood by those skilled in the art of solenoid design. In particular, the solenoid may be cased or framed in a soft steel outer tube 19 which will tend to confine the flux in the radial direction.

Preferably the solenoid has a soft steel tubular core 20 extending from end-to-end, to like effect, and the end faces of this liner core and of tube 19 will act as keepers for one or other of magnets 16, 18, that is to say hold the actuator in one or other position against movement, at times when there is no energising current in windings 13 and little or no residual electromagnetic field in solenoid 12.

Preferably also the permanent magnets have soft steel casings 22, 24 covering all except the faces adjacent the solenoid. They will channel the flux appropriately.

It will be appreciated that actuator 10 has a bistable latching property. Not only is rod 14 displaced, i.e. actuated when current is supplied in the appropriate switched direction, but actuator 10 remains latched in the switched position even when solenoid 12 is not energised until reverse current is applied, and then it displaces and again remains latched in the new position, and so on.

The value of the applied current requires to be dependant upon the characteristics of actuator 10 itself, and also of the associated door latch or other mechanism which is to be powered by the actuator.

An example of a door locking assembly 30 so powered is shown in Figures 2-4, forming part of a CDL system of a vehicle. Actuator 10 is mounted on a body 32 of the assembly with an extension of rod 14 pivotally connected to an arm of a CDL locking lever 34. Appli-

cation of current of appropriate polarity to the solenoid of actuator 10 under the control of a central logic module of the system in known manner will shift lever 34 between a locked condition (Figure 3) and an unlocked condition (Figure 4). The above latching property ensures that the mechanism is retained in the selected condition without further power requirement until a subsequent operation.

In this first version, it is the adjacent faces of the permanent magnets 16, 18 which are effective.

For some purposes, it may be preferred to provide more than one solenoid and these could act in either a series or a parallel arrangement, possibly with extra permanent magnets. This may have advantages in enabling a physically different shape to be used, as appropriate to enable the actuator to be fitted into confined dimensions or a space of awkward contour as in or on a vehicle latch or lock assembly, and in providing extra power and/or latching security.

In the second form of actuator 40 shown in Figure 5 a pair of coils 42, 44 is wound around the respective limbs 46, 48 of a U shaped core 50 (one coil on each limb) and with the limbs extending beyond the coils at their free ends. The windings/switchings are such that said free end of one limb of the U is of one polarity when the electromotive field exists as a result of the electrical energisation, and the free end of the other limb is of opposite polarity. Two permanent magnets 52, 54 located with like poles adjacent lie between the free ends of limbs 46, 48 and are attracted/repelled between limbs 46, 48 according to the energisation, and remain latched by the permanent magnetism when the coils are de-energised. Again this provides bistable latching. Magnets 52, 54 are arranged on opposite faces of a lever 56 pivoted on a fulcrum 58 in the bridge of the U shape, the free arm 60 of the lever opposite to the magnets being used to provide the required drive output of the actuator. As will be plain to the man in the art, different required displacement strokes can be provided by adjustment of the ratio of dimensions between the fulcrum and the ends of the lever, for any one value of actual magnetic movement, although different magnetic displacement is also possible to give different actuation effects.

Actuator 40 may be incorporated into a CDL system locking assembly 62 as in Figure 6, the actuator forming an end part of the generally rectangular assembly conveniently contained in a common housing 64 to form a compact unit. The arm 60 coacts with the locking mechanism to effect remotely controlled locking and unlocking of the assembly, and/or superlocking thereof for added security of the associated door or other closure by disabling manual mechanical release of the lock from both the inside and outside of the vehicle in known manner.

A third form of actuator 70 (Figures 7 and 8) also provides angular movement of a component carrying permanent magnets. A member 72 (Figure 7) extending only radially of a fulcrum axis 74 (instead of diametrically as in the second described version) is fast with a spindle 76 extending along that axis. The spindle is then part-rotated by movement of a pair of magnets 78, 80 mounted on the distal end of member 72 with like poles adjacent as in the second example.

In this version a single coil 82 is arranged as a wound part-toroid extending over the major part of the periphery of C-shaped ferrite or similar core 84, e.g. having a diameter of 50mm, the opposite ends of the core winding providing areas of opposite polarity at the core end faces when the winding is energised. Magnets 78, 80 lie within the gap between the core ends. This design can be particularly compact in one dimension, and again provides bistable latching. In Figure 7 the spindle 76 is centred within the core.

In the arrangement shown in Figure 8 the spindle 76a is spaced outside the core 84 to give more direct drive input to locking mechanism of a CDL system locking assembly 62a of the same type as shown in Figure 6, with member 72a extending into the core gap and carrying the magnets 78, 80 on its distal end as above.

It will be appreciated that the invention also contemplates arrangements in which a single permanent magnet, for example a horse-shoe magnet, or a pair of magnets with opposite poles adjacent, co-acts with a solenoid having oppositely handed coil winding sections giving like magnetic polarity at its opposite ends, which polarity is reversed by switching the current to provide relative movement between the solenoid and magnet or magnets.

It is also contemplated that in some constructions the solenoid might be displaceable to provide the drive output with the magnets in fixed relationship thereto, or both the magnets and the solenoid might be displaceable in opposite directions to provide drive in the manner of a push-pull linkage.

Claims

1. An electrically powered actuator (10) for selectively driving a movable element (14) to and fro between first and second positions characterized in that the actuator comprises:

   (a) solenoid means (12) having two first poles (12a, 12b) and coil windings (13) for operative connection to switching means whereby the direction of current flow in the windings can be selected to determine the polarity of magnetic flux at said two first poles;

   (b)permanent magnet means (16, 18) having a respective second pole (16a, 18a) positioned in co-acting relationship to each said first poles;

   the solenoid means and the permanent magnet means being mounted for relative movement driv-

ing said movable element, one of the first poles abutting or being brought into close proximity to one of the second poles at the first position but being spaced from each other with the other of the first poles abutting or being brought into close proximity to the other of the second poles at the second position; whereby application of current to the coil windings causes one first pole formation to have unlike polarity to its co-acting second pole formation to provide an attractive magnetic force in a first direction and another first pole formation to have like polarity to its co-acting second pole formation to provide a repulsive magnetic force in the same first direction urging the movable element to the first position, and application of current to said windings in the opposite direction causes reversal of polarity of the first pole formations urging the movable element to the second position.

2. An actuator as in Claim 2 characterized in that the permanent magnet means comprises a pair of permanent magnets (16, 18) physically connected together with one pole (16a, 18a) of each magnet constituting said second poles and the magnets moving as a pair within the electro-magnetic field of the solenoid means (12) to drive the movable element (14).

3. An actuator as in Claim 2 characterized in that the solenoid means (12) has coil windings (13) arranged to cause magnetic flux at the two first poles (12a, 12b) of opposite polarity to each other, the said one poles (16a, 18a) of the permanent magnet means (16, 18) having the same magnetic polarity as each other.

4. An actuator as in Claim 2 or 3 characterized in that the solenoid means (12) is cylindrical with the first poles (12a, 12b) at its opposite ends, and the permanent magnets (16, 18) are linked with their respective second poles (16a, 18a) facing each other in co-acting relationship to the solenoid poles.

5. An actuator as in Claim 2 or 3 characterized in that the movable element (56:72:72a) is pivoted for angular displacement between the first and second positions and the permanent magnets (52,54: 78,80) are mounted on opposite sides of said element so that the second poles face away from each other; and in that the solenoid has a U-shaped or part-toroidal core (50;84) with one or more coil windings (42,44;82) thereon providing first poles defining a gap within which the permanent magnets move between the first and second positions.

6. An actuator as in any preceding claim wherein the coil windings (13) of the solenoid means (12) have a core (20) of soft steel and/or a casing or frame (19) of soft steel functioning as a keeper to enhance the latching effect of the permanent magnet means retaining the movable element (14) at the selected positions even when the coil windings (13) are not energized.

7. An actuator as in any preceding claim characterized in that parts of the permanent magnet means other than the second poles have soft steel casings (22, 24).

8. A vehicle door locking assembly (30) characterized in that it includes an actuator (10) as in any preceding claim.

9. An assembly as in Claim 8 characterized in that it is operatively connected as part of a central door locking system of the vehicle, and in that the actuator (10) operates a central door locking lever (34) of the assembly.

10. A vehicle central door locking system characterized in that it includes a locking assembly (30) as in Claim 8 or 9.

11. A vehicle characterized in that it includes a door locking assembly or a central door locking system as in claim 7,8,9 or 10.

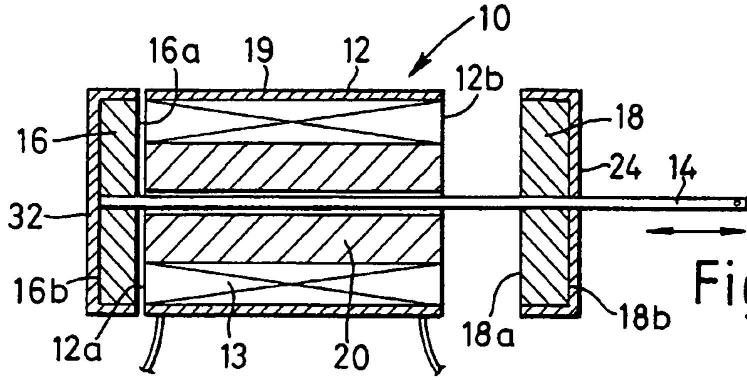

Fig.1

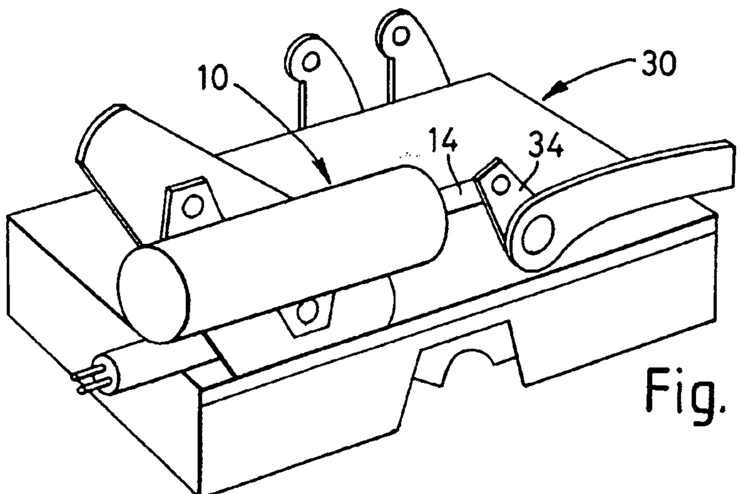

Fig. 2

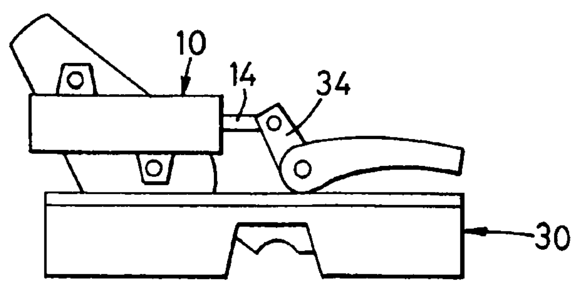

Fig. 3

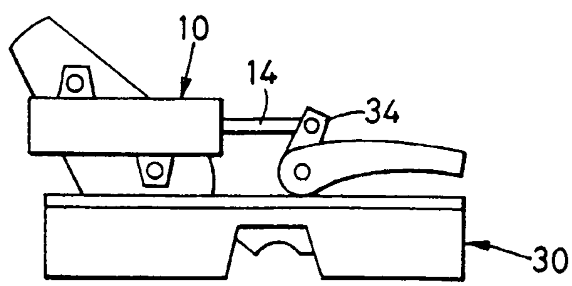

Fig.4

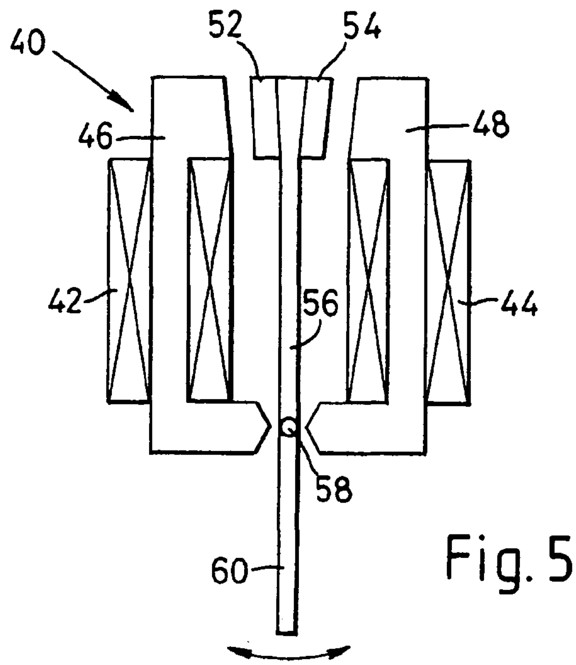

Fig. 5

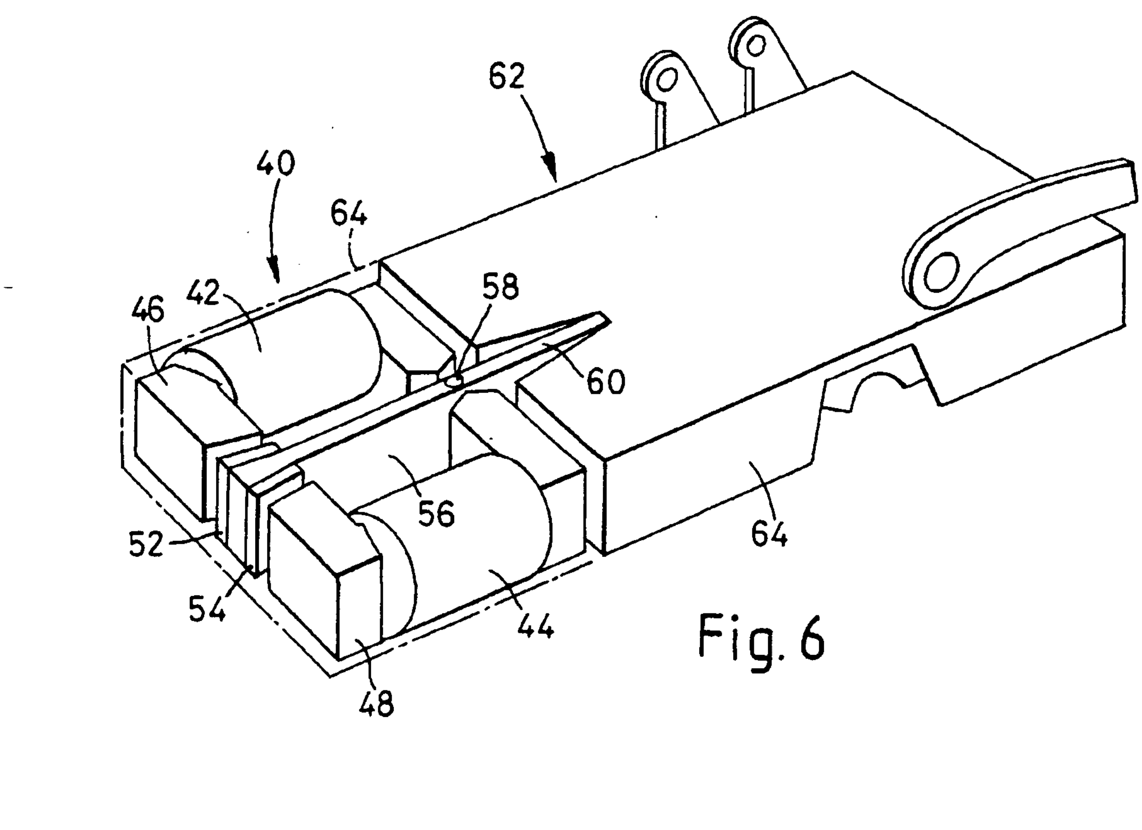

Fig. 6

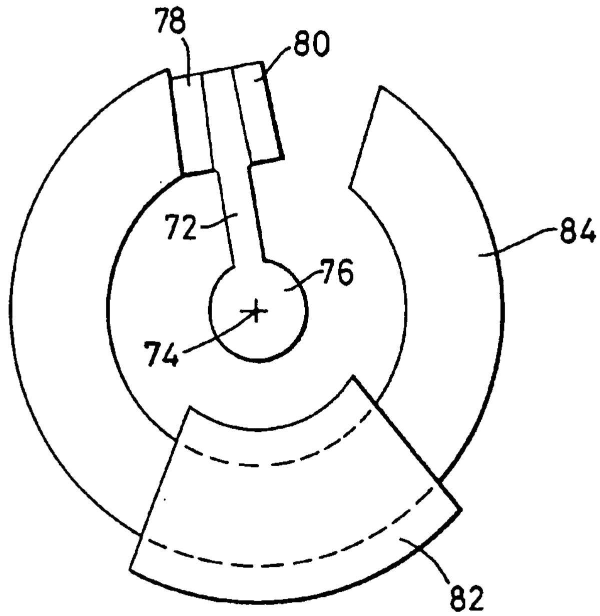

Fig.7

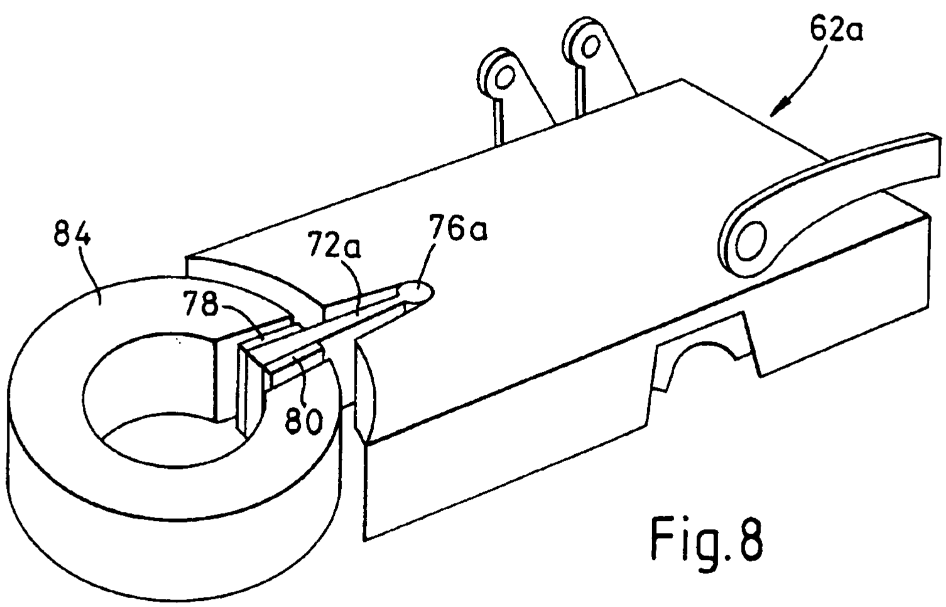

Fig.8

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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 6115

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	GB-A-2 227 608 (H U DEV CORP) 1 August 1990 * figure 4 * ---	1-4,6,7	H01F7/16 H01F7/14
A	US-A-3 928 988 (LUTH CLAUS-PETER) 30 December 1975 * figures 1,2 * ---	5	
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 059 (E-482), 24 February 1987 & JP-A-61 220310 (SHIYUUKOU DENSHI KK), 30 September 1986, * abstract * ---		
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 119 (E-248), 5 June 1984 & JP-A-59 032111 (KIYOSHI HAMA;OTHERS: 01), 21 February 1984, * abstract * ---		TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	FR-A-2 315 754 (MECANISMES COMP IND DE) 21 January 1977 -----		H01F H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 November 1996	Vanhulle, R

CATEGORY OF CITED DOCUMENTS

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